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Evaluation of endodontically treated maxillary premoalrs restored with bulk fill composite resin, short fibre reinforced composite resin with and without overlay: An in-vitro study

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Abstract

Aim: To evaluate and compare the fracture resistance of mesio-occluso-distally involved endodontically treated maxillary premolars with/without an overlay preparation restored using different bulk fill composite resin and full crown restorations.

Methodology: Standardized MOD cavities were prepared on 75 freshly extracted human maxillary premolars which were then subjected to endodontic treatment. The specimens were divided into 5 groups (n=15) based on preparation design and materials employed as: G1- MOD restored with nanohybrid composite, G2- MOD overlay with 2.5mm cuspal reduction restored with nanohybrid composite , G3- MOD restored with fibre reinforced composite veneered with nanohybrid composite, G4- MOD overlay with 2.5mm cuspal reduction restored with fibre reinforced composite veneered with nanohybrid composite and G5- MOD cavity restored with nanohybrid composite followed by PFM crow. Specimens were subjected to thermocycling and fracture resistance testing using Universal Testing Machine to assess the fracture resistance and mode of failure. One-way ANOVA test followed by Tukey's HSD Post hoc Analysis were done to compare the fracture resistance between 5 groups. Chi square test was used to compare the mode of failure between the groups.

Result: Highest fracture resistance was recorded in Group 4 followed by Group 3, Group 5, Group 2, Group 1 respectively (mean load at fracture was 1339.96 ± 174.65, 1246.98 ± 183.42, 855.00 ± 95.60, 630.81 ± 61.09 and 427.00 ± 50.52 respectively) at $P < 0.001$. While Group 1, 2, 5 showed predominantly unfavorable fractures occurring below CEJ. Group 3 & 4 showing

predominantly favourable fractures (above CEJ). However, the difference in the mode of fracture between different study groups was not statistically significant [P=0.14].

Conclusion: Fracture resistance of endodontically treated maxillary premolars with MOD with/without an overlay preparation restored with fibre reinforced composite-nanohybrid combination was statistically higher compared to bulk fill nanohybrid composite resin and full crown restorations, with MOD overlays faring better compared to Intracoronal restorations.

Keywords: ETT, MOD, HSD, ANOVA

Introduction

Fracture resistance of endodontically treated teeth (ETT) to a greater extent depends on the amount of remaining tooth structure. Loss of coronal tooth structure could be due to caries, fractures or previous restorations. So, whenever there was sufficient amount of sound coronal tooth structure remaining following endodontic treatment, indirect inlay/Onlay preparations was considered as alternative restoration options.

With advances in the adhesive technology and composite resin material, direct composites with better biomechanical behaviour, good esthetic properties, relatively low cost, ease of handling and preservation of dental structures - many clinicians prefer to use it in various applications 4. The fracture resistance of ETT restored with just the composite resin as direct access cavity filling material has not shown any drastic change in the tooth's fracture resistance.

The latest bulk fill composite materials showed less polymerisation shrinkage, require less chairside time, easy to manipulate and have better physico-mechanical properties. The difference in their chemical monomeric resin formulation and filler characteristics, such as the type, volume fraction, density, particle size and distribution justify their numerous applications.

Ever X posterior is yet another newer dentine replacement bulk fill composite material with e-glass fibers and barium glass filler in BIS EMA resin matrix. It bonds well to tooth and other BIS GMA resin materials without any added clinical step. This short-fiber composite is thought to increase the fracture resistance of the restored teeth by preventing crack propagation and facilitating uniform stress distribution.

Aware of the best properties of both these bulk fill materials (nanohybrid and fibre reinforced composite), the effect of combining Ever X Posterior for dentine with already available nanohybrid composite resin on fracture resistance of ETT when used as a direct restorative material with or without cuspal coverage is still not evaluated and compared to just the nanohybrid or full crown restorations.

Hence, this in-vitro study was designed with an aim to evaluate and compare the fracture resistance of ETT premolars restored using different bulk fill composites-nanohybrid and fibre reinforced with and without an overlay design to conventionally used full crown restorations.

Materials and Methodology

The present in-vitro study was conducted in laboratory setting with prior institutional ethics committee approval. The power of the study was considered at 80% with alpha error at 5% and sample size determination was done with G Power v.5.2, to obtain a sample size of 75. Seventy-five intact human non carious, double rooted Maxillary first premolars extracted for orthodontic reasons were collected from Department of Oral Surgery at Dayananda Sagar College of Dental Sciences. Any teeth which were carious, with previous restoration, fractures or endodontic treatment and

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hypoplastic defects were excluded. Teeth were cleaned and stored in 0.5% Chloramine-T solution.

Sample preparation

Splints were prepared to simulate the exact occlusal tooth anatomy to be used later during restoration. Polyvinyl siloxane (light body) impression material was coated around the roots of the teeth 2mm below the CEJ and mounted in a cylindrical plastic mould 1 mm below the CEJ using chemically cured acrylic resin to simulate the periodontal ligament and alveolar bone. (Fig 1) Standardised through and through MOD preparations were done measuring 3mm buccolingually with gingival margin 1mm above the CEJ. Resulting root canal orifices were pre enlarged, prepared to F2 Protaper rotary files using X smart endomotor (Dentsply) and 3% NaOCl and 17% EDTA. Root canals were obturated using F2 Protaper cones (25mm, 8%) and AH Plus sealer. GP was sheared off 2mm below CEJ. (Fig 2)

Grouping	
Group 1	MOD access cavity restored completely with bulk fill nanohybrid composite.
Group 2	MOD access cavity with 2.5mm cuspal reduction restored completely with bulk fill nanohybrid composite as an overlay.
Group 3	MOD access cavity restored with short e-glass fibre reinforced composite resin as dentin replacement material followed by nano hybrid composite resin
Group 4	MOD access cavity with 2.5mm cuspal reduction restored with short e-glass fibre composite as dentin replacement material followed by nano hybrid composite as an overlay
Group 5	MOD access cavity restored with bulkfill composite followed by PFM crown.

Figure 1: Occlusal stents for final restoration

Figure 2: 2.5MM reduction of CUSP for overlay

Figure 3: Crown preparation for PFM

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Figure 4: Final Restoration

Process

Tofflemire matrix band and retainer adapted around the MOD cavity. Teeth specimens were etched with 37% orthophosphoric acid for 15 s, rinsed with water for 20s, gently blow dried, bonding agent (two step etch and rinse technique) applied as per manufacturers instruction, cured for 20 seconds, followed by composite restoration. Proximal wall build up was done for all the samples with bulk fill composite resin.

Group 1: The cavity was then filled with the same bulk fill nanohybrid composite and cured for 20s.

Group 2: 2.5mm cuspal reduction of both buccal and palatal cusp was done. The cavity was filled with nanohybrid bulkfill composite and cured. Occlusal anatomy was reproduced using the previously prepared stent.

Group 3: The access cavity was restored with Ever X posterior composite resin and cured for 20 s and layered with nano hybrid composite resin of 1.5mm and cured for 20s as per manufactures instructions.

Group 4: 2.5mm cuspal reduction of both buccal and palatal cusp was done, the cavity was filled with Ever X posterior composite resin cured for 20s and layered with nano hybrid composite resin of 1.5mm and cured for 20s. Previously prepared stents were used to reproduce the occlusal anatomy.

Group 5: Access cavity was restored with bulk fill composite resin. Crown preparation was done with reduction of 1.5mm of functional cusp and 1mm reduction of non-functional cusp with a shoulder finish line measuring 1mm for PFM crowns. The crowns were cemented using luting GIC. (Fig 3 and Fig 4)

Thermo-cycling and assessment

The samples were thermocycled at 500 cycles at 50° C and 550° C with a dwell time of 30s and subjected to fracture testing using Universal testing machine. A rounded end stainless steel antagonist of diameter 3mm at a cross head speed of 0.5mm/minute was used to apply a load along the long axis of the tooth until fracture.

The obtained data was compiled systematically. A master table was prepared and the dataset was subdivided and distributed meaningfully and presented as individual tables along with graphs on a Microsoft excel worksheet (Microsoft, USA).

Statistical Analysis

Statistical analysis was done with Statistical Package for Social Sciences (IBM SPSS Statistic for windows, version 21.0. Armonk, NY: IBM Corp.) the distribution of the data set was assessed with normality test (Shapiro-Wilk test). Descriptive statistics were performed for all the findings. Mean and standard deviation (SD) were calculated.

Statistical tests employed for the obtained data in our study were:

Inter group comparison

1. The observations being continuous in nature parametric test were applied to compare the inter-group findings with One-way ANOVA test followed by Tukey's HSD Post hoc Analysis

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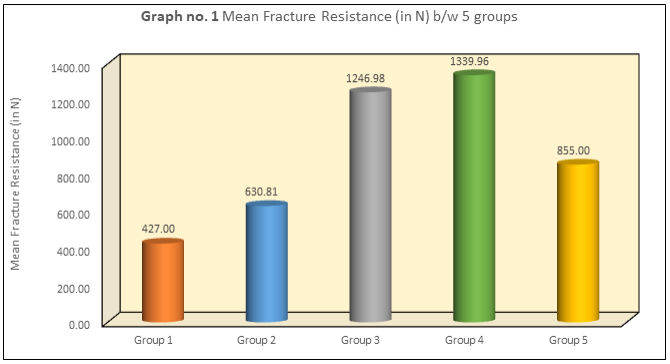
2. The observations were then assessed based on the chi-square values and mean values.

The mean difference was analysed. The p values of <0.05 was considered to be statistically significant at 95% confidence interval.

Results

The statistical analysis was performed with SPSS version 21. The data recorded was entered in Microsoft excel sheet. The normality of the data was check with normality test. Descriptive statistics includes expression of fracture resistance in terms of mean and standard deviation (SD). One-way ANOVA test followed by Tukey's HSD Post hoc Analysis was used to compare the fracture resistance between 05 groups. Chi square test was used to compare the mode of fracture. The level of significance [p-Value] was set at p<0.05.

The test results demonstrate that the mean Fracture Resistance for Group 1 was 427.00 ± 50.52, Group 2 was 630.81 ± 61.09, Group 3 was 1246.98 ± 183.42, Group 4 was 1339.96 ± 174.65 and Group 5 was 855.00 ± 95.60. This mean difference in the Fracture Resistance between 4 groups was statistically significant at P<0.001 Graph 1.



The test results showed that Group 4 showed significantly higher Fracture Resistance as compared to Group 1, 2 & 5 at P < 0.001. This was then followed next with Group 3 showing significantly higher mean Fracture Resistance as compare to Group 1, 2 & 5 groups at P<0.001. This was followed with Group 5 showing significantly higher mean Fracture Resistance as compared to Group 1 & 2 at P<0.001. Finally, Group 2 also showed significantly higher mean Fracture Resistance as compared to Group 1 at P<0.001. However, no significant was observed for mean fracture resistance between Group 3 & Group 4 [P=0.27]. This infers that the mean Fracture Resistance was significantly higher in Group 4, Group 3, Group 5, Group 2 & least with Group 1 [Table 1]

The test results demonstrated that Group 1 & Group 2 showed predominantly unfavorable fractures of 53.3% & 40.0% respectively, which was followed by Group 5 showing 33.3% unfavorable fractures. This was in contrast with Group 3 & Group 4 showing predominantly favourable fractures of 80% & 86.7% respectively. However, the difference in the mode of fractures between different study groups was not statistically significant [P=0.14]. [Table 1].

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Table 1: Comparison of mean Fracture Resistance (in N) b/w 4 groups using One-way ANOVA Test

Groups	N	Mean	SD	Min	Max	P-Value
Group 1	15	427.00	50.52	307	484	<0.001*
Group 2	15	630.81	61.09	535	765	
Group 3	15	1246.98	183.42	952	1587	
Group 4	15	1339.96	174.65	1069	1596	
Group 5	15	855.00	95.60	655	994	

Comparison of Fracture Mode between different study groups using Chi Square Test

Fracture Mode	Group 1		Group 2		Group 3		Group 4		Group 5		P-Value
	n	%	n	%	n	%	n	%	n	%	
Favourable	7	46.7%	9	60.0%	12	80.0%	13	86.7%	10	66.7%	0.14
Unfavorable	8	53.3%	6	40.0%	3	20.0%	2	13.3%	5	33.3%	

Discussion

Success of structurally compromised ETT depends mainly on the post endodontic restoration 5,8. Tang *et al*. suggested that the ETT with MOD preparations are more prone to cuspal deflection and fractures than the ones with either MO/DO cavities 9.

It is a well-known fact that, the removal of sound tooth structure is inevitable during root canal procedure and post-endodontic restoration which further reduces the tooth's fracture toughness 10. So, while restoring an ETT to normal form and function, one has to be careful in selecting an appropriate restorative material that has sufficient strength to withstand functional forces and reinforce the weakened ETT 11.

Full coverage crowns which are routinely advocated following ETT, results in further loss of sound tooth structure46 and other minimally invasive, indirect overlay restorations were less retentive and had the same shortcomings as full crowns 12.

Magne et al evaluated the fracture resistance of ETT, with varying thicknesses of cuspal reduction (1.5, 2.5, and 3.5 mm) and concluded that thicker composite resin overlays of atleast 2.5mm provided better strength properties 14. With greater cuspal reduction and a thicker composite restoration, there will be less deflection of the restoration to the flexural forces and the stresses get more uniformly distributed throughout the restoration and also along the long axis of the remaining tooth 15. Hence, we have standardised our overlay preparation design to 2.5mm thickness.

On evaluating the results of our study, it was found that Group 4- MOD overlay with fibre reinforced composite showed highest mean load at fracture (1339.96 ± 174.65) followed by group 3-MOD with fibre reinforced composite (1246.98 ± 183.42), group 5-full crown (855.00 ± 95.60), group 2- MOD overlay with nanohybrid (630.81 ± 61.09) and group 1- MOD nanohybrid restoration (427.00 ± 50.52) at $P < 0.001$.

This goes to say that, fibre reinforced bulk fill direct composite restorations showed significantly higher fracture strength compared to nanohybrid bulk fill and traditional full crown restorations. This could be because of its composition consisting of e-glass fibers in short interpenetrating resin matrix that help in redistribution of functional forces19. Better light penetration would have

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resulted in optimal curing of the material, thereby overcoming issues of polymerisation shrinkage.

Mean load at fracture exhibited by Full crown (group 5) was better compared to group 1,2 ie., MOD nanohybrid composite with/without overlay (group 1,2). This is in accordance with previous studies done by Cheung et al and Shu et al suggesting ETT with full crown restorations, encircling the tooth 360 degrees provided a bracing effect. However, its fracture resistance was inferior compared to group 3,4 MOD direct fibre reinforced composite with/without overlay restorations 16. This could be due to additional tooth structure removed during full crown preparation such as cuspal ridges, marginal ridge, pericervical dentine would have reduced the tooth's fracture resistance resulting in lower mean load at fracture. The height and the width of Peri cervical dentine also has a major role to play in tooth's fracture toughness, as the stresses most commonly accumulated in this critical area. Edelhoff & Sorensen (2002) reported that conventional full crown preparations with buccal shoulders (1.4 mm) and lingual chamfers (0.7 mm) removed substantial amount (75.6%) of tooth structure. All these drastically would have decreased the fracture resistance of ETT maxillary premolar with MOD preparation which was quite extensive17-19. Fibre reinforced direct composite on the other hand would have reinforced the structurally weakened endodontically treated maxillary premolar due to its better bonding and stress distribution properties. 20 Ever X posterior, is a recently introduced fibre reinforced bulk fill composite material consisting of inorganic particulate fillers in combination with a semi-interpenetrating polymer network matrix of Bis-EMA, TEGDMA and PMMA 21. Shorter e-glass fibres with 0.5 and 1.6mm diameter is thought to provide a degree of toughness that is equivalent to dentin, greater depth of light penetration, better curing of composite resin, better stress distribution, inhibition of crack propagation22. It is indicated as dentine replacement material due to its elastic modulus for high stress bearing areas and as access filling material 21.

Though, we have compared two different bulk fill composite resin restorative materials, fibre reinforced Ever X posterior veneered with nanohybrid composite showed better properties compared to Tetric N ceram nanohybrid material alone. Also, bulk fill overlay restorations showed higher fracture resistance compared to MOD intracoronal restorations for ETT.

Further analysing the fracture pattern, it was seen that Group 1, 2 and 5 (nanohybrid, full crown restorations) showed predominantly unfavorable fractures, occurring below CEJ (53.3%, 40.0% and 33.3% respectively). Group 3 & Group 4 (fibre reinforced composite) showed predominantly favorable fractures occurring above CEJ (80% & 86.7% respectively). However, the difference in the mode of failure between different study groups was not statistically significant [P=0.14].

Combination of fibre reinforced-nanohybrid bulk fill composite with or without provided better fracture resistance compared to bulk fill nanohybrid composite material alone and can safely be advocated for ETT maxillary premolars with MOD preparations, without a much change in their fracture resistance.

Conclusion

The following conclusions could be drawn on evaluating the fracture resistance of ETT maxillary premolars restored with bulk fill nanohybrid, fibre reinforced composite with /without an overlay preparation as against full crown restoration

1. Fracture resistance of endodontically treated maxillary premolars with MOD with/without an overlay preparation was highest with fibre reinforced-nanohybrid

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composite combination as compared to nanohybrid composite resin alone or full crown restorations.

2. Fracture resistance of endodontically treated maxillary premolars with MOD overlay restored with bulk fill composite material was better compared to MOD intracoronal bulk fill composite resin or full crown restorations.

3. Fracture resistance of endodontically treated maxillary premolars with MOD preparation restored with direct fibre reinforced-nanohybrid composite combination was higher compared to direct nanohybrid composite alone.

4. Fracture pattern of endodontically treated maxillary premolars with MOD with /without an overlay showed that, combination of bulk fill fibre reinforced composite veneered with nanohybrid composite resin showed favorable fractures located above CEJ-which are easily repairable, as compared to full crown and direct nanohybrid composite materials.

However, further in-vitro, long-term clinical studies evaluating various other physico-mechanical properties are required before such minimally invasive bulk fill direct overlay restorations can be routinely advocated as alternative to full crown restorations.

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